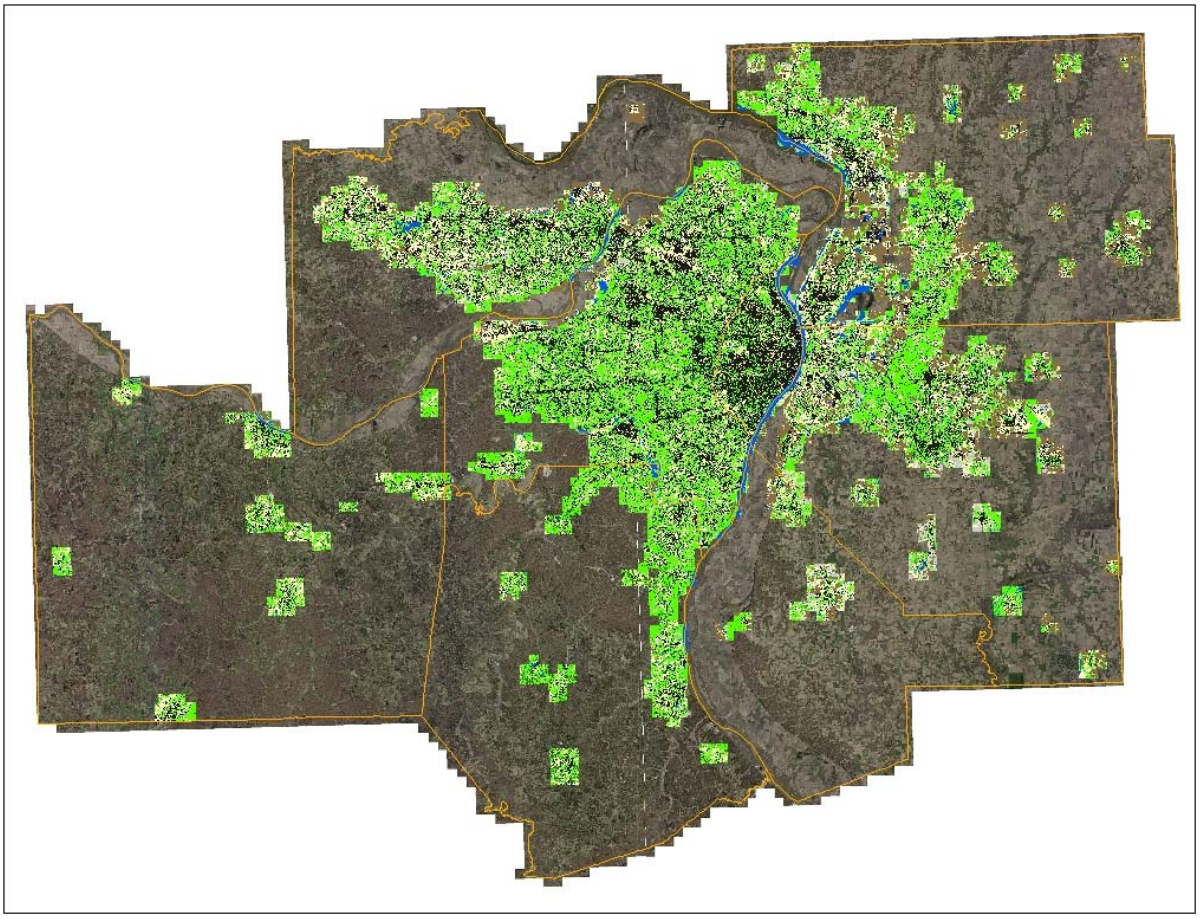
Fine-resolution Land Use / Land Cover Data Development

Final Report for FY2017

June 2017



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East-West Gateway staff and partners completed fine-resolution maps of about 30% of the urban area within the region in FY2016. Efforts for FY2017 have (1) improved the FY2016 results, and (2) completed mapping for the rest of the urban areas in the region in two phases (Figure 1).

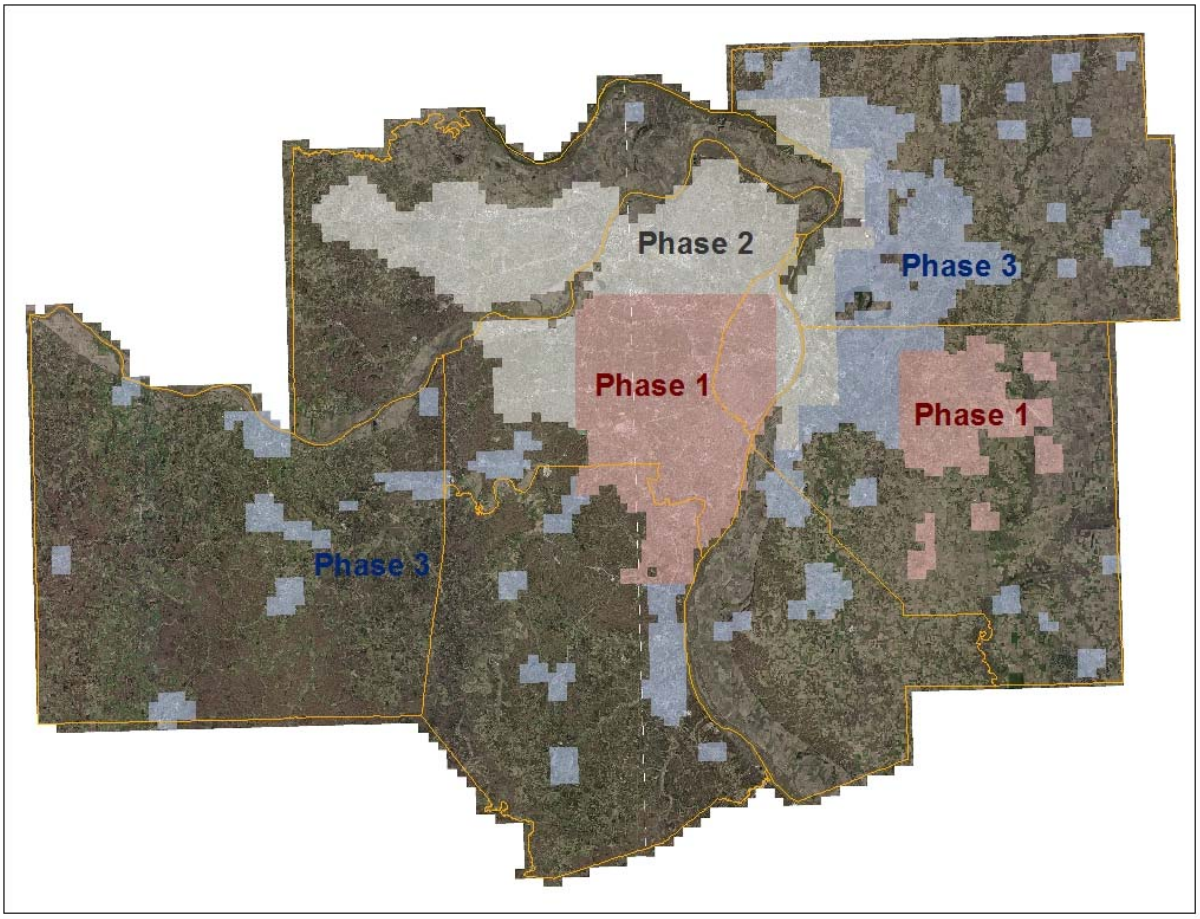

Figure 1. Phase 2 and Phase 3 of the urban mapping project were completed in FY2017. Results from Phase 1 were improved.

Methods

Identification of Urban Mask

The most recent National Landcover Dataset (NLCD, 2011) was used to create the urban mask. All areas that were >35% urban land cover within a 1 square kilometer neighborhood (circle with a radius of 564 m) were included in the urban mask. Since Lidar data comes in tiles (usually 1 square kilometer), we selected Lidar data tiles that fully circumscribed the irregularly-shaped mask. Thus, the final analysis area used for production consists of the boundaries of square Lidar data tiles that circumscribe areas with more than 35% urban land cover within a 1 square kilometer neighborhood (see outlined area, Figure 1). Only relatively small or isolated urban features were excluded from analysis, and substantial areas on the urban/rural fringe are included.

Generation of Image Objects

Image objects (polygons with similar visual properties) were generated at 1 m resolution using eCognition software. Input data included 2015 leaf-off imagery collected at 6-inch resolution and re-sampled to 1 m, 2014 National Agriculture Imagery Program (NAIP) leaf-on imagery, and Lidar from a variety of recent years (Figure 2). Variables used to generate the image objects included values from 4 bands of reflectance data for each year, surface height of buildings or trees, and a normalized difference vegetation index (an index to greenness) generated from infrared and red reflectance bands in the air photos. We tested use of 3 m and 5 m resolution image objects but results were most satisfactory when 1 m resolution objects were generated.

Figure 2. Image objects (yellow lines) were generated from leaf-off and leaf-on air photos and Lidar data.

Classification of Land Cover

We targeted seven land use / land cover categories for classification:

1. Urban/Impervious – roof tops, paved roads, paved lots
2. Open Water
3. Row Crops – croplands that were not fallow in both dates of imagery
4. Grassland – includes lawns, fescue fields, forb-dominated areas
5. Evergreen Woody Vegetation (e.g. eastern redcedar, planted pine)
6. Deciduous Woody Vegetation (e.g. oak, elm, ash, hackberry, etc.)
7. Barren/Sparsely Vegetated – unpaved lots, new developments, fields fallow in both dates of imagery

Each image object had 105 variables attached by eCognition, including attributes related to the air photo reflectance bands, Lidar height, object texture, and object shape. These variables were used to classify the image objects using Random Forest, a decision tree classifier. Separate classifications were done for Illinois and Missouri, because the quality of the 2014 NAIP imagery was lower for IL than for MO. To accomplish each classification, more than 8000 objects that represented at least 900 samples of each of the seven land use / land cover classes were selected for training. The classification process was iterative: successive refinements were made by adding training data until the classification achieved a high degree of accuracy. The classification model was then applied to all objects in the MO and IL data sets.

On-screen Data Modification

We systematically panned across all classified image objects with the 2015 leaf-off air photos and 2014 leaf-on NAIP as reference, flashing off and on the classified objects over the imagery, looking for mistakes in the results. When mistakes were noted, we selected misclassified image objects and re-coded them to the correct land use / land cover category. An initial systematic pass was done for the extent of the study area at 1:4,000 resolution, and a second worker made a second pass at 1:10,000 resolution. Both workers zoomed in to view suspected mistakes at finer resolution before re-coding image objects, when needed. A second round of on-screen modifications were done based on new methods developed in FY2017 (details below).

Improving Results (Innovations Developed in FY2017)

We implemented improvements in methods for FY2017 in order to sharpen the classification. Original 6-inch imagery was used in eCognition to create a raster-based NDVI (green-ness) and built-up area index (BAI). These values were used to sharpen the edges of urban image objects by shrinking or growing the 1 m resolution objects based on the 6-inch resolution NDVI and BAI raster values (Figure 3). In addition, height (generated from Lidar) was used to separate trees from lawns/grasses within the 'sharpened' product. The result was better separation of lawns (primarily) and urban trees from impervious cover (roads, sidewalks, buildings). Finally, all urban image objects that were changed to trees via the above process over 150 square meters were viewed on-screen to ensure that they were correctly identified. This step was needed primarily because some green roof-tops were mistakenly identified as trees. Minimal efforts were made to identify roads beneath tree canopy; rather, the presence of the tree canopy over roads was considered important to document.

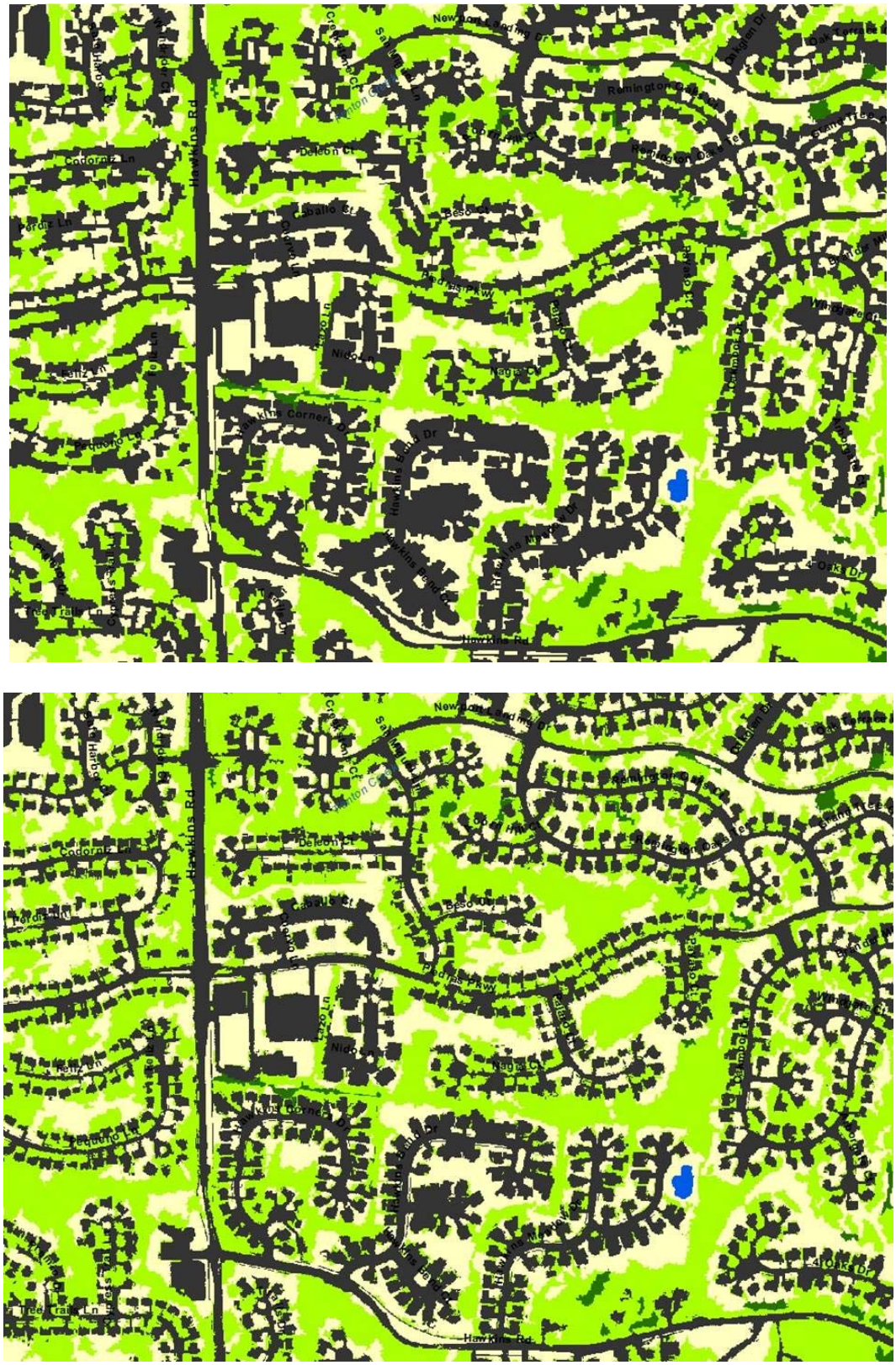

Figure 3. New methods helped sharpen results by using 6 in imagery. Top image captured before corrections, and bottom image after corrections.

Results

The accuracy of the classification results was determined via selection of stratified random accuracy assessment points. Objects (1437 points were used to select objects for assessment) were assigned to one of the seven classes based on visual inspection of air photos. In some cases a sample point was assigned to a 'first call; and a 'second call' because a definitive determination of class could not be made based on the air photo interpretation. Row crops that consisted of fallow field in both dates of air photo acquisition were considered correctly classified if assigned to either row crop or barren. Accuracy statistics were as follows:

MO: 87.25% correct; 92.50% correct if the second call was included (where one was made).
IL: 84.99% correct; 87.90% correct if the second call was included (where one was made).

These statistics were generated before corrections were made via heads-up review or application of the methodology that sharpened results, so the accuracy of the current map should be improved over what is listed above.

A total of 355,773 hectares were within the urban assessment area. Missouri had 216,598 hectares (60.38%) of the area, and Illinois had 142,175 hectares (39.62%)(Table 1).

Table 1. Land cover by state within an urban assessment area created for the East-West Gateway planning region (see Figure 1).

	Illinois		Missouri	
Land cover type	**Area (ha)**	**Percentage[1]**	**Area (ha)**	**Percentage[1]**
Urban/Impervious	23613	16.61%	58232	26.88%
Row Crops	28271	19.89%	6545	3.02%
Open Water	6391	4.50%	5531	2.55%
Grassland	35903	25.25%	58932	27.21%
Evergreen Woody Vegetation	945	0.66%	4379	2.02%
Deciduous Woody Vegetation	39727	27.94%	79645	36.77%
Barren/Sparsely Vegetated	7323	5.15%	3333	1.54%

[1]Percentage area given based on total classified areas at the state level for Illinois and Missouri, which were 142,175 ha and 216,598 ha, respectively.

More deciduous woodland that urban/impervious land cover was recorded within the urban assessment area, and about the same amount of grassland as urban/impervious was mapped (Figure 3).

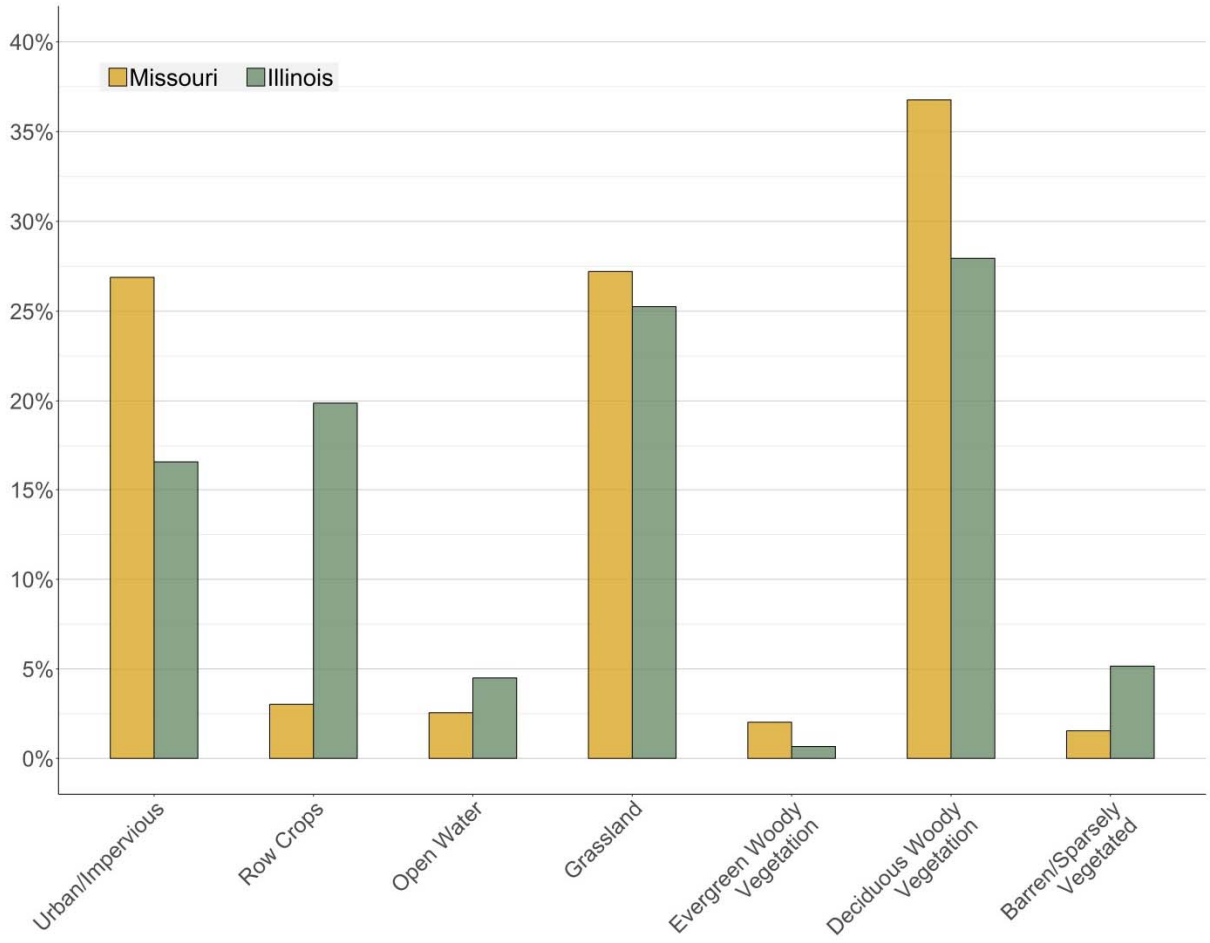

Figure 4. Land cover within the urban assessment area by state.

Even within heavily developed St. Louis City, only 54.2% of the land cover was urban/impervious, whereas deciduous woodland accounted for 22.0% and grassland 18.0% of the land cover (Figure 4, Table 2). Franklin, Jefferson, Madison, Monroe, and St. Clair Counties all contained less than 20% urban/impervious cover within the urban assessment area, which was generated at coarser resolution. Many of these counties have smaller urban areas that are surrounded by, or circumscribe patches of, natural and semi-natural vegetation.

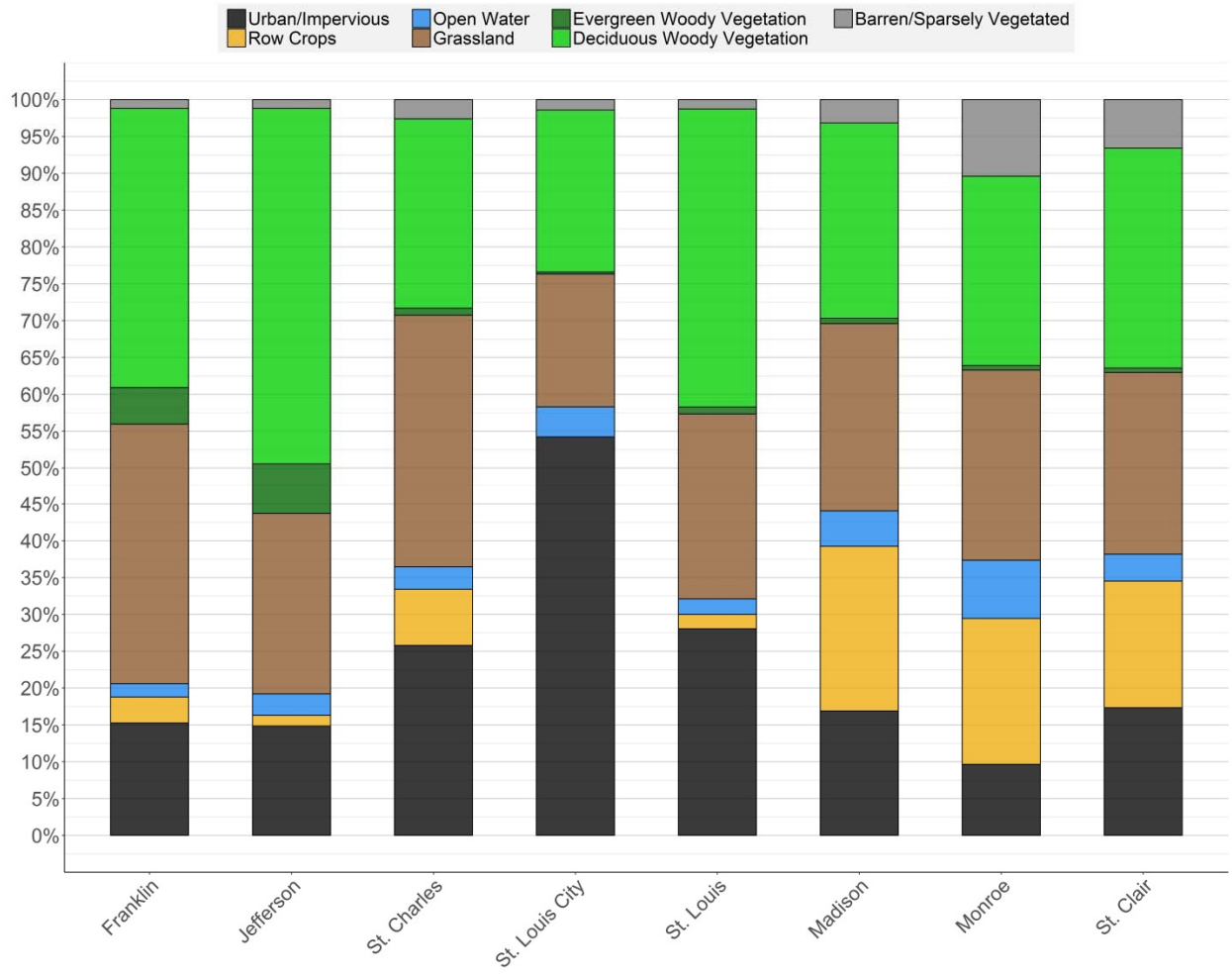

Figure 5. Land cover within the urban assessment area by county.

Table 2. Land cover summary within the urban assessment area by county.

		Urban/ Impervious		Row Crops		Open Water		Grassland		Evergreen Woody Vegetation		Deciduous Woody Vegetation		Barren/Sparsely Vegetated		County Total
State	County	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)
MO	*Franklin*	2544	15.3%	587	3.5%	300	1.8%	5890	35.4%	825	5.0%	6313	37.9%	197	1.2%	16656
	Jefferson	4496	14.9%	438	1.4%	881	2.9%	7417	24.5%	2071	6.8%	14614	48.3%	358	1.2%	30276
	St. Charles	11645	25.8%	3443	7.6%	1370	3.0%	15480	34.3%	428	0.9%	11605	25.7%	1180	2.6%	45152
	St. Louis City	9567	54.2%	0	0.0%	720	4.1%	3177	18.0%	50	0.3%	3881	22.0%	248	1.4%	17643
	St. Louis	29981	28.1%	2076	1.9%	2259	2.1%	26967	25.2%	1004	0.9%	43233	40.5%	1350	1.3%	106870
IL	*Madison*	11757	16.9%	15553	22.4%	3340	4.8%	17784	25.6%	509	0.7%	18451	26.5%	2192	3.2%	69587
	Monroe	914	9.6%	1878	19.8%	748	7.9%	2459	25.9%	60	0.6%	2435	25.7%	985	10.4%	9479
	St. Clair	10942	17.3%	10840	17.2%	2303	3.6%	15660	24.8%	376	0.6%	18841	29.9%	4147	6.6%	63108

Visual inspection of the map reveals an appealing result. Prior to production of this map, some partners were disappointed that features such as Forest Park and the grounds of the Missouri Botanical Gardens, which were correctly classified as mainly urban at coarser resolution, were not immediately apparent on earlier maps. These areas of reduced urban development are clearly visible on the new map because it was produced from much finer-grained data (Figure 6).

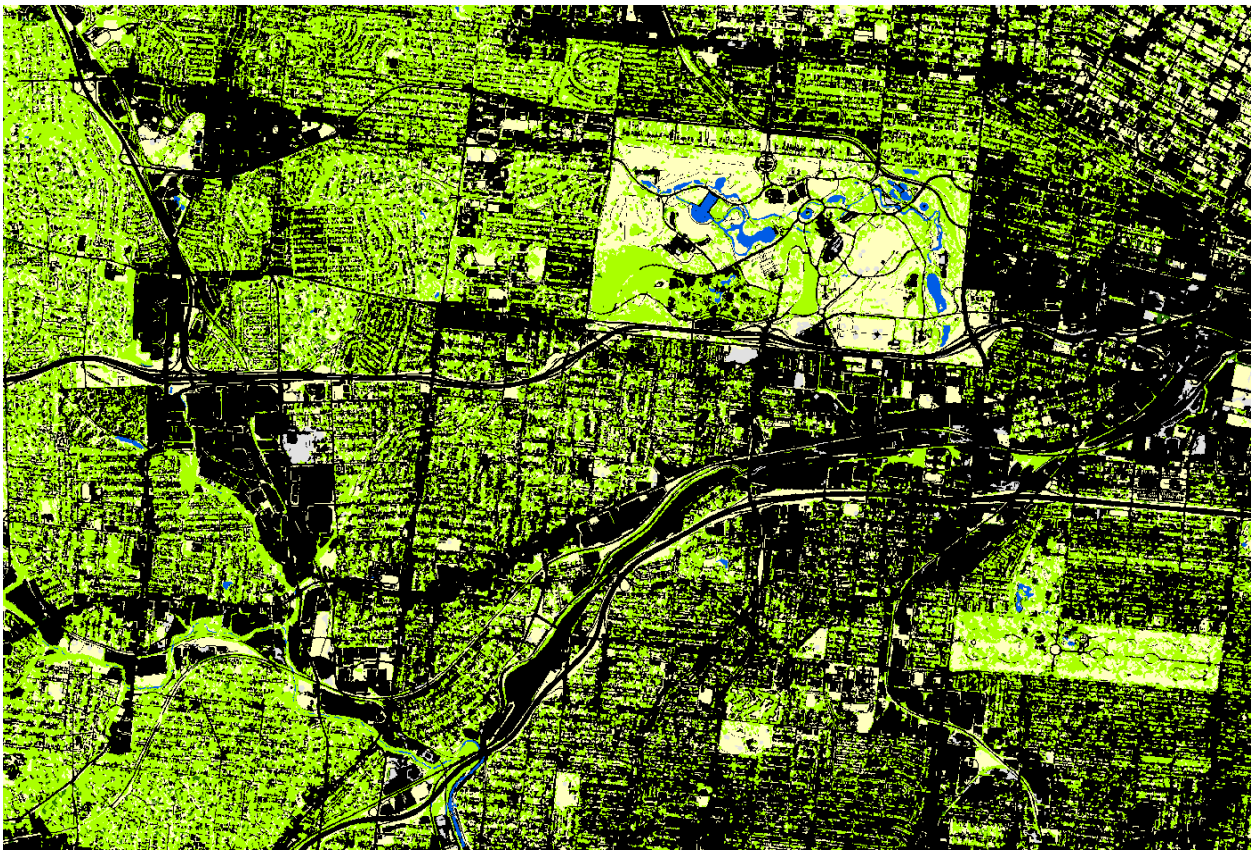

Figure 6. Seven-class land use / land cover classification for a portion of the East-West Gateway region. The rectangular features that stand out are Forest Park (upper right) and the Missouri Botanical Gardens/Tower Grove Park (lower right).